

**OROVILLE FERC RELICENSING  
(PROJECT No. 2100)**

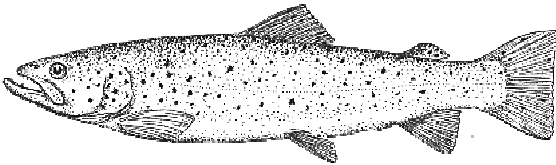
**INTERIM REPORT  
SP-F3.2 TASK 2  
SP-F21 TASK 1**

**APPENDIX A  
MATRIX OF LIFE HISTORY AND HABITAT REQUIREMENTS FOR  
FEATHER RIVER FISH SPECIES**

**LITERATURE REVIEW OF LIFE HISTORY AND  
HABITAT REQUIREMENTS FOR  
FEATHER RIVER FISH SPECIES**

**BROWN TROUT**

**JANUARY 2003**

Element	Element Descriptor	General	Feather River Specific
<b>General</b>			
common name (s)	English name (usually used by fishers and laypeople).	Brown trout	
scientific name (s)	Latin name (referenced in scientific publications).	<i>Salmo trutta</i>	
taxonomy (family)	Common name of the family to which they belong. Also indicate scientific family name.	Salmon, trout, and char – <i>Salmonidae</i>	
depiction	Illustration, drawing or photograph.		
range	Broad geographic distribution, specifying California distribution, as available.	Brown trout are native to Europe, North Africa, and Asia. Brown trout have been established in the USA, Canada, South America, Falklands, Africa, Australia, New Zealand, and Papua New Guinea (Moyle 2002).	
native or introduced	If introduced, indicate timing, location, and methods.	Brown trout were introduced to North America in 1883, and introduced into California in 1893 when embryos were brought in and successfully reared for planting in coastal streams (Moyle 2002).	

Element	Element Descriptor	General	Feather River Specific
ESA listing status	Following the categories according to California Code of Regulations and the Federal Register, indicate whether: SE = State-listed Endangered; ST = State-listed Threatened; FE = Federally listed Endangered; FT = Federally-listed Threatened; SCE = State Candidate (Endangered); SCT = State candidate (Threatened); FPE = Federally proposed (Endangered); FPT = Federally proposed (Threatened); FPD = Federally proposed (Delisting); the date of listing; or N = not listed.	Not listed.	
species status	If native, whether: Extinct/extirpated; Threatened or Endangered; Special concern; Watch list; Stable or increasing. If introduced, whether: Extirpated (failed introduction); highly localized; Localized; Widespread and stable; Widespread and expanding.	Freshwater. Widespread and stable.	
economic or recreational value	Indicate whether target species sought for food or trophy. Whether desirable by recreational fishers, commercial fishers, or both.	Brown trout have a high recreational value. They provide some of the finest angling to avid recreational fishers because of their bottom feeding and piscivorous tendencies and their natural wariness (Moyle 2002).	
warmwater or coldwater	Warmwater if suitable temperature range is similar to basses; coldwater if suitable temperature range is similar to salmonids.	Coldwater.	
pelagic or littoral	Environment: Pelagic - living far from shore; Littoral - living near the shore.		

Element	Element Descriptor	General	Feather River Specific
bottom or water column distribution	Environment: bottom (benthic) or along water column.	Adults are largely bottom-oriented pool dwellers in streams and rivers (Moyle 2002).	
lentic or lotic	Environment: Lentic - pertaining to stagnant water, or lake-like; Lotic - moving water, or river-like.	Young and small brown trout are found in riffles and pools. Reported optimal habitat conditions are medium to large, slightly alkaline, clear streams with swift riffles and large deep pools (Moyle 2002).	
<b>Adults</b>			
life span	Approximate maximum age obtained.	The oldest recorded age, in the alpine lakes of Norway, is 38 yrs. In California, the oldest recorded age is 9 years (Moyle 2002).	
adult length	Indicate: Length at which they first reproduce; average length and maximum length the fish can attain.	<p>In California, brown trout reach lengths of 1.2–3.15 inches (3-8 cm) TL in the first year, typically averaging 2–2.8 inches (5-7 cm) TL. In the second year, brown trout reach lengths of 2.8–8.7 inches (7-22 cm) TL, typically averaging 5.1–6.3 inches (13-16 cm). In the third year, brown trout reach lengths of 5.1 –14.2 inches (13-36 cm) TL, typically averaging 7.5–11 inches (19-28 cm). In the fourth year they reach lengths of 9.1–17.7 inches (23 –45 cm) TL, averaging 13.8–16.1 inches (35-41 cm) (Moyle 2002).</p> <p>Brown trout mature in 2-3 years, but few may wait to spawn for 7-8 years (Moyle 2002).</p> <p>Brown trout mature at the end of the first year or as late as the eighth year, but most mature between the third and fifth year (Raleigh R.F. et al. 1986).</p> <p>Most males mature at age 4 and females at age 5, at lengths generally ranging from 12–19 inches (30.1–48.3 cm). However, some mature individuals were reported as small as 5 or 6 inches (12.7–15.2 cm) (Raleigh R.F. et al. 1986).</p>	
adult weight	Indicate: Weight at which they first reproduce; average weight and maximum weight the fish can attain.	<p>The largest known brown trout caught was a sea-run individual caught in Scotland measuring 40.6 inches (103 cm) TL and weighing 39.7 lbs (18 kg) (Moyle 2002).</p> <p>The largest fish recorded in California weighed 26.5 lbs (12 kg), caught in Upper Twin Lake (Moyle 2002).</p>	
physical morphology	General shape of the fish: elongated, fusiform, laterally compressed, etc.		

Element	Element Descriptor	General	Feather River Specific
coloration	Indicate color, and color changes, if any, during reproduction phase.	Brown trout have red and black spots on the body and adults are usually dark brown to olive brown dorsally, shading to yellow-brown on the sides, and white to yellow ventrally (Moyle 2002).	
other physical adult descriptors	Unique physical features for easy identification.	Brown trout is the only species of trout in California with both red and black spots on the body (Moyle 2002).	
adult food base	Indicate primary diet components.	Brown trout vary in their prey selection. Trout greater than 9.8 inches (>25 cm) TL feed on crayfish, terrestrial insects, dragonfly larvae, and their own young. At greater than 15.7 inches (>40 cm), they feed exclusively on fish (Moyle 2002).	
adult feeding habits	Indicate whether plankton eater, algae eater, bottom feeder, piscivorous, active hunter, ambush predator, filter feeder. Night, day, dusk or dawn feeder.	Most terrestrial insects are fed upon during the day, but brown trout feed most intensely at dawn and dusk. They are also active hunters in the evening (Moyle 2002).	
adult in-ocean residence time	For anadromous species, age when they migrate to the ocean and duration spent in the ocean before returning to freshwater to spawn.	N/A	
adult habitat characteristics in-ocean	For anadromous species, description of the ocean habitat utilized: whether along major current systems, gyres, pelagic (beyond continental shelves) and neritic (above continental shelves) zones, etc.	N/A	
<b>Adult upstream migration (immigration)</b>			
range of adult upstream migration timing	Time of year adults migrate upstream. If applicable, indicate for various runs.	N/A	
peak adult upstream migration timing	Time of year most adults migrate upstream. If applicable, indicate for various runs.	N/A	

Element	Element Descriptor	General	Feather River Specific
adult upstream migration water temperature tolerance	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	N/A	
adult upstream migration water temperature preference	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental.	N/A	
<b>Adult holding (freshwater residence)</b>			
water temperature tolerance for holding adults	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	<p>Brown trout can survive water temperatures up to 82.4°F–94.2°F (28°C–29°C) for short periods of time, depending on the acclimation temperature. Adult brown trout prefer water temperatures ranging from 53.6°F–68°F (12°C–20°C). High growth rates occurred at water temperatures ranging from 53.6°F–64.4°F (12°C–18°C), and optimal growth is reported to occur at 62.6°F–64.8°F (17°C–18°C) (Moyle 2002).</p> <p>Brown trout can survive at temperatures of 32°F–80.6°F (0°C– 27°C) (Raleigh R.F. et al. 1986).</p> <p>The reported lethal water temperature for brown trout is 81°F (27.2°C) (Raleigh R.F. et al. 1986).</p>	
water temperature preference for holding adults	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental.	<p>Reported preferred water temperatures for brown trout are 53.6°F–68°F (12°C–20°C). If given a choice, brown trout will avoid water temperatures greater than 55.4°F (&gt;13°C) (Moyle 2002).</p> <p>Reported preferred water temperatures for brown trout are 53.6°C–66.2°F (12°C–19°C) (Raleigh R.F. et al. 1986).</p>	
water depth range for holding adults	Reported range of observed (minimum and maximum) water depth utilization.	<p>Brown trout can be found at water depths of 2.3–11.5 feet (0.7–3.5 meters) (Moyle 2002).</p> <p>Brown trout were found at water depths of 0.2 to 5.5 feet (0.1–1.7 meters) (Raleigh R.F. et al. 1986).</p>	
water depth preference for holding adults	Reported range of most frequently observed water depth utilization.	<p>Adult brown trout preferred depths of 2.3–11.5 feet (0.7–3.5 meters) (Moyle 2002).</p> <p>Adult brown trout prefer resting and feeding at a water depth of 0.5 feet- (&gt;15-cm) (Raleigh R.F. et al. 1986).</p>	

Element	Element Descriptor	General	Feather River Specific
substrate preference for holding adults	If bottom dwellers, indicate substrate: mud, sand, gravel, boulders, aquatic plant beds, etc. If gravel, indicate range or average size of gravel.	Adult brown trout prefer streams with riffles that have pea- to walnut-sized gravel (Moyle 2002).  The optimal substrate for maintenance of a diverse invertebrate community, which trout feed on, is reported to consist of a mosaic of gravel, rubble, and boulders, with rubble dominating (Raleigh R.F. et al. 1986).	
water velocity range for holding adults	Reported range of observed (minimum and maximum) water velocity utilization.	Brown trout inhabit areas with variable water velocities (Moyle 2002).  Adult brown trout utilize water velocities of 0–0.7 ft/sec (0–21.3 cm/sec) for resting, and 0.5–1.5 ft/sec (15.2–45.7 cm/sec) for feeding (Raleigh R.F. et al. 1986).	
water velocity preference for holding adults	Reported range of most frequently observed water velocity utilization.	Brown trout typically prefer relatively low velocities (Moyle 2002).  The water velocity preferred for resting and feeding adult brown trout is less than 0.49 ft/sec (<15 cm/sec) (Raleigh R.F. et al. 1986).	
other habitat characteristics for holding adults	General description of habitat (e.g. turbid or clear waters, lentic or lotic, presence of aquatic plant beds, debris, cover, etc.).	Reported optimal riverine habitat is characterized by clear, cool to cold water; relatively silt-free rocky substrate in riffle-run areas; a 50-70% pool to 30-50% riffle-run habitat combination, with areas of slow, deep water; well-vegetated, stable stream banks; abundant instream cover; relatively stable annual flow and water temperatures. Brown trout also occupy the lower reaches of river systems in areas of low to moderate gradients (<1%) (Raleigh R.F. et al. 1986).  Escape cover for adults and juveniles is provided by overhanging and submerged vegetation, undercut banks, instream objects such as debris piles, logs, and large rocks. Greater than 35% cover of the total stream area provides adequate cover for adult brown trout (Raleigh R.F. et al. 1986).	
timing range for adult holding	Time of year (earliest-latest) and duration of stay from upstream migration to spawning.	N/A	

Element	Element Descriptor	General	Feather River Specific
timing peak for adult holding	Time of year when maximum number of adults are present before spawning.	N/A	
<b>Spawning</b>			
fecundity	Average or range in the number of eggs females lay in a spawning season.	Female brown trout can lay anywhere from 200 to 21,000 eggs, which is partially dependent on the size of the female. Females typically lay 77-103 eggs/inch (30-40 eggs/cm) of their FL (Moyle 2002).	
nest construction	Location and general description of nest -- substrates, aquatic plants, excavations, crevices, habitat types, etc.	The redd site is determined by the female, who turns on her side and begins to form a depression in the gravel by digging with her tail, which is known as cutting (Moyle 2002).	
nest size	Size and average dimensions of the nest.	Brown trout redds vary in length from 11.8–42.1 inches (30–107 cm) (Raleigh R.F. et al. 1986).	
spawning process	Indicate whether nest builder, broadcast spawner, or other.	Nest builder (Moyle 2002).  Brown trout generally move upstream in the fall to spawn or, in the case of lakes and reservoirs, into tributaries. Females build redds in the gravel and demersal eggs are deposited and covered with gravel. Nests are left unguarded. Brown trout usually spawn in running water (Raleigh R.F. et al. 1986)	
spawning substrate size/characteristics	Range of substrates used during spawning (e.g. mud, sand, gravel, boulders, beds of aquatic plants). Indicate presence of plant/wood debris, crevices at spawning sites. If gravel, indicate range of average size.	Brown trout have been observed using gravel 0.12-3.9 inches (0.3-10 cm) in diameter as a spawning substrate (Raleigh R.F. et al. 1986).	
preferred spawning substrate	Indicate preferred spawning substrate (e.g. mud, sand, gravel, boulders, plant bed, etc).	Brown trout prefer to spawn in gravel ranging from 0.39-2.8 inches (1-7 cm) in diameter (Raleigh R.F. et al. 1986).	
water temperature tolerance for spawning	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	Brown trout have been observed spawning in water temperatures of 42.8°F–55°F (6°C-12.8°C) (Raleigh R.F. et al. 1986).	
water temperature preference for spawning	Range of suitable, preferred or reported optimal water temperatures. Indicate whether	Brown trout prefer to spawn in water temperatures within the range of 42.8°F–50°F (6°C–10°C) (Moyle 2002). Brown trout prefer to spawn in water temperatures within	



Element	Element Descriptor	General	Feather River Specific
	literature, observational, or experimental derivation.	the range of 44.6°F–48.2°F (7°C–9°C) (Raleigh R.F. et al. 1986).	
water velocity range for spawning	Minimum and maximum speed of water current the spawning fish can tolerate.	Water velocity over redds in the Yellowstone River ranged from 1.58–2.5 ft/sec (48.2–75.9 cm/sec). In Oregon, water velocities near spawning sites ranged from 0.67–2.2 ft/sec (20.4–68.3 cm/sec) with an average of 1.5 ft/sec (44.5 cm/s). Oregon populations of brown trout were observed spawning in water velocities of 0.45–1.5 ft/sec (13.7–45.7 cm/sec) as well (Raleigh R.F. et al. 1986).	
water velocity preference for spawning	Preferred water current (flow velocity) during spawning.	The reported optimal water velocity range for spawning was found to be 1.7–2.3 ft/sec (53.3–68.6 cm/sec). An average preferred velocity also was reported as 1.3 ft/sec (39.4 cm/sec) (Raleigh R.F. et al. 1986).  A habitat suitability index model suggests that the optimal water velocity for brown trout spawning is 1.3–2.3 ft/sec (40–70 cm/sec) (Raleigh R.F. et al. 1986).	
water depth range for spawning	Reported range of observed (minimum and maximum) water depth utilization.	Minimum spawning water depth ranges from 0.2–0.8 ft (0.06–0.2 m), while suitable water depth for spawning ranged from 0.4–3.0 ft (12.2–91.4 cm) (Raleigh R.F. et al. 1986).	
water depth preference for spawning	Reported range of most frequently observed water depth utilization.	Reported optimal water depth for spawning ranged from 0.8–1.5 ft (24.4–45.7 cm) (Raleigh R.F. et al. 1986).	
range for spawning timing	Earliest and latest time of season or year in which spawning occurs.	Spawning takes place in fall or winter (Moyle 2002).  Spawning takes place from October through February, depending on the location (Raleigh R.F. et al. 1986).	
peak spawning timing	Time of year most fish start to spawn.	In California, spawning commonly takes place in November and December (Moyle 2002).	
spawning frequency (iteroparous/semelparous)	Semelparous - producing all offspring at one time, such as in most salmon. Usually these fish die after reproduction. Iteroparous - producing offspring in successive, e.g., annual or seasonal batches, as is the case in most fishes.	Brown trout are iteroparous	

Element	Element Descriptor	General	Feather River Specific
<b>Incubation/Early development</b>			
egg characteristics	Shape, size, color, in clusters or individuals, stickiness, and other physical attributes.		
water temperature tolerance for incubation	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	Water temperatures of 56°F (13.3°C) are lethal to eggs (Raleigh R.F. et al. 1986).  The water temperature tolerance of the eggs ranges from 32°F–59°F (0°C–15°C) (Raleigh R.F. et al. 1986).	
water temperature preference for incubation	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.	Reported optimal water temperature range for egg development, hatching success and fry emergence ranges from 44.6°F–53.6°F (7°C–12°C) and 43.9°F–55.04°F (6.6°C–12.8°C), depending on the location. For embryonic development, suitable water temperatures range from 41°F–55.4°F (5°C–13°C) (Raleigh R.F. et al. 1986).	
time required for incubation	Time duration from fertilization to hatching. Note: Indicate at which temperature range. Incubation time is temperature-dependent.	The time required for egg incubation ranges from 4–21 weeks depending upon water temperature, but typically lasts 7–8 weeks (Moyle 2002).  Incubation lasts 148 days at 35.4°F (1.9°C) and 34 days at 52.1°F (11.2°C) (Raleigh R.F. et al. 1986).  Incubation can require anywhere from 33 – 165 days, depending on the water temperature (Raleigh R.F. et al. 1986).	
size of newly hatched larvae	Average size of newly hatched larvae.		
time newly hatched larvae remain in gravel	Time of year of hatching, and duration between hatching and emergence from gravel.	The newly hatched larvae remain in the gravel 3-6 weeks before they emerge (Moyle 2002).  Brown trout embryos overwinter in gravel, with fry emerging from the gravel in early spring. Dispersal of fry takes place immediately after emergence (Raleigh R.F. et al. 1986).	
other characteristics of larvae	Alevin -- early life history phase just after hatching (larva) when yolk-sac still present.	Fry prefer pools and rocky substrates, but often are excluded from these areas by older and larger juvenile trout, which also prefer these areas (Raleigh R.F. et al. 1986).	

Element	Element Descriptor	General	Feather River Specific
timing range for emergence	Time of year (earliest-latest) hatchlings (larvae and alevins) leave or emerge from the nesting/hatching (gravel) sites.	Emergence generally occurs during the December through April period (Raleigh R.F. et al. 1986).	
timing peak for emergence	Time of year most hatchlings emerge.	Brown trout embryos overwinter in gravel, with fry emerging from the gravel in early spring (Raleigh R.F. et al. 1986).	
size at emergence from gravel	Average size of hatchlings at time of emergence.		
<b>Juvenile rearing</b>			
general rearing habitat and strategies	General description of freshwater environment and rearing behavior.	Juveniles stay at the tails of pools where the water is deeper, currents are less turbulent, and cover is close by. The fry live in quiet water close to shore among large rocks or under overhanging plants. Require streams with riffles that have pea- to walnut-sized gravel (Moyle 2002).	
water temperature tolerance for juvenile rearing	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	<p>Juveniles can survive water temperatures ranging from 32°F–80.6°F (0°C–27°C) (Raleigh R.F. et al. 1986).</p> <p>The lower limit of water temperature for growth of juveniles is reported as 43°F (6.1°C) and the maximum water temperature tolerated is reported as 81°F (27.2°C) (Raleigh R.F. et al. 1986).</p> <p>The mean upper short term lethal water temperatures for stream-resident brown trout juveniles was reported as 29°C (Raleigh R.F. et al. 1986).</p>	
water temperature preference for juvenile rearing	Range of suitable, preferred, or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.	<p>Adequate growth occurred at water temperatures ranging from 44.6°F–66.2°F (7–19°C), with reported optimal growth occurring at 53.6°C (12°C) (Raleigh R.F. et al. 1986).</p> <p>Water temperatures ranging from 7°C–19°C is given as the assumed water temperature optima for juvenile brown trout (Raleigh R.F. et al. 1986).</p> <p>Juvenile brown trout showed a preference for 17.6°C in a laboratory experiments (Raleigh R.F. et al. 1986).</p>	
water velocity ranges for rearing juveniles	Reported range of observed (minimum and maximum) water velocity utilization.	Fry prefer slow water velocities, while juvenile brown trout select waters with higher velocities, ranging from 0.33–0.13 ft/sec (10.1– 4 cm/sec) (Moyle 2002).	

Element	Element Descriptor	General	Feather River Specific
water velocities preferred by rearing juveniles	Reported range of most frequently observed water velocity utilization.	Both fry and juveniles prefer velocities of less than 0.49 ft/sec (15 cm/s) (Raleigh R.F. et al. 1986).	
water depth range for juvenile rearing	Reported range of observed (minimum and maximum) water depth utilization.	Juvenile brown trout occur at shallower water depths than adults. As growth progresses, water depths of greater than 6 inches (15 cm) are preferred (Raleigh R.F. et al. 1986).	
water depth preference for juvenile rearing	Reported range of most frequently observed water depth utilization.	Fry typically choose edge water less than 11.8 inches (30 cm) in depth, while juvenile or yearling brown trout select deeper water ranging from 20-30 inches (50-75 cm) in depth (Moyle 2002).	
cover preferences for rearing juveniles	Type of cover for protection from predators used by rearing juveniles (e.g. crevices, submerged aquatic vegetation, overhanging vegetation, substrate cover, undercover bank, small woody debris, large woody debris).	Juveniles prefer cover consisting of large rocks, logs, and overhead cover. Larger individuals (greater than 9.8 inches or 25 cm in TL) remain under cover (e.g., undercut banks, logs) during the day (Moyle 2002).	
food base of juveniles	Indicate primary diet components. Also indicate the diet changes, if any, as growth occurs.	The food base of juveniles is mainly drift organisms, especially terrestrial insects. As they grow larger, brown trout juveniles spend more time selectively picking benthic invertebrates from the bottom of the stream. Once they exceed 9.8 inches (25 cm) TL, brown trout actively pursue large prey such as fish (including their own young), crayfish, and dragonfly larvae (Moyle 2002).	
feeding habits of rearing juveniles	Indicate whether plankton eater, algae eater, bottom feeder, piscivorous, active hunter, ambush predator, filter feeder. Night, day, dusk or dawn feeder. Also indicate change of feeding habits growth occurs.	Brown trout remain under cover during the day and come out to pursue prey at night (Moyle 2002).	
predation of juveniles	Indicate which species prey on juveniles.		
timing range for juvenile rearing	Range of time of year (months) during which rearing occurs.	In-river rearing occurs year-round (Raleigh R.F. et al. 1986).	
timing peak for juvenile rearing	Time of year (months) during which most rearing occurs.	In-river rearing occurs year-round (Raleigh R.F. et al. 1986).	

Element	Element Descriptor	General	Feather River Specific
<b>Juvenile emigration</b>			
time spent in fresh water prior to emigrating	Duration (in years and/or months) from emergence to emigration to the ocean.	N/A	
water temperature tolerances during emigration	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	N/A	
water temperature preferences during emigration	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.	N/A	
emigration timing range	Time of year juveniles commence emigration and duration of emigration.	N/A	
emigration timing peak	Time of year most juveniles are emigrating.	N/A	
size range of juveniles during emigration	Minimum and maximum sizes (inches or mm) of emigrating juveniles. Indicate average size.	N/A	
factors associated with emigration	Pulse flows, water temperature changes, turbidity levels, photoperiod, etc.	N/A	
<b>Other potential factors</b>			
DO	Levels of dissolved oxygen in water expressed in mg/L tolerated by fish.	<p>Optimal dissolved oxygen levels for brown trout are not well-documented, but optimal dissolved oxygen levels for adult brown trout appear to be greater than 12 mg/L at water temperatures greater than 50°F (10°C). Adult brown trout avoid water with dissolved oxygen concentrations of less than 5 mg/L (Raleigh R.F. et al. 1986).</p> <p>The incipient lethal level of dissolved oxygen for adult and juvenile brown trout is approximately 3 mg/l or less, depending on environmental conditions such as water temperature. Although fish may survive at concentrations just above this level, they must make various physiological adaptations to accommodate survival, which may jeopardize their health. Low levels of dissolved oxygen can cause reduced fecundity and prevent spawning. Large</p>	

Element	Element Descriptor	General	Feather River Specific
		<p>fluctuations in dissolved oxygen result in a loss of appetite and impaired growth (Raleigh R.F. et al. 1986).</p> <p>Dissolved oxygen requirements for brown trout fry and juveniles are not well documented. The authors recommend a minimal to optimal dissolved oxygen concentration ranging from 3 to 27 mg/L at water temperatures less than 59°F (15°C) and a minimal to optimal dissolved oxygen concentration ranging from greater than 5 to 29 mg/L at water temperatures greater than 59°F (15°C). Deaths of juveniles occurred at dissolved oxygen concentrations of 1.6 to 2.8 mg/L with water temperatures ranging from 48.2°F to 69.8°F (9 to 21°C). Half of the juveniles were dead at oxygen concentrations of 1.5 to 2.5 mg/L, and all of the juveniles were dead at 1.3 to 2.3 mg/L dissolved oxygen. Mean lethal dissolved oxygen levels ranged from 1.42 mg/L at 48.9°F (9.4°C) to 2.53 mg/L at 68.9°F (20.5°C) (Raleigh R.F. et al. 1986).</p>	
pH	Alkalinity/acidity of water (expressed in pH) that fish can tolerate.	Juveniles and adults tolerate a pH ranging from 5.0–9.5, but optimal growth occurs at a pH ranging from 6.8–7.8 (Raleigh R.F. et al. 1986).	
turbidity	Indicate turbidity or state of water (e.g., clear water or presence of siltation or organic/inorganic matter in water) that fish can tolerate.	Small young brown trout are found in riffles and pools; however, the optimum habitat for the brown trout seems to be medium to large clear streams with swift riffles and large, deep pools (Moyle 2002).	
factors contributing to mortality	e.g., fishing/angling mortality, drastic habitat alterations, unfavorable climatic changes, etc.	The embryonic and alevin stages are critical for brown trout populations in CA because high winter flows can scour the developing fish out of the gravel, resulting in small or absent year classes (Moyle 2002).	

## References

- Moyle, P. B. 2002. Salmon and Trout, Salmonidae - Brown Trout (*Salmo Trutta*) in Inland Fishes of California. Los Angeles, California: University of California Press, 293-296.
- Raleigh R.F., Zuckerman L.D., and P. C. Nelson. 1986. Habitat Suitability Index Models and Instream Flow Suitability Curves: Brown Trout. Report # Biol. Rep. 82(10.124). U.S. Fish Wildl. Serv.